Bs reaches North America, Lips predicts, "the newts are going to be the tinder for a fire."

Bs is already spreading, having crossed from the Netherlands into Belgium. Its relative Bd is known to spread via amphibians or other animals, or simply by floating downstream. The key to preventing Bs from becoming another Bd, many researchers believe, is to clamp down on the small but often lucrative global trade in amphibians. An estimated 2.3 million Chinese fire belly newts (*Cynops orientalis*) were imported into the United States between 2001 and 2009, according to a recent study. In Europe, officials have some legal tools for regulating the trade, but rarely use them. A new E.U. animal health law, expected next year, could help, says geneticist Matthew Fisher of Imperial College London, who studies wildlife diseases. "It will be more aggressive," he predicts.

In the United States, no agency directly regulates imports of salamanders or other amphibians. "It's a clear example of why we need to modernize our laws," says Peter Jenkins, a consultant with the Center for Invasive Species Prevention in Washington, D.C. Congress is considering bills to give the U.S. Fish and Wildlife Service (FWS) more authority and tools, but antiregulation lawmakers have helped stall the proposals.

The pet trade is open to improved regulation, says Marshall Meyers of the Pet Industry Joint Advisory Council in Washington, D.C. He points out that the largest pet companies already treat imported amphibians with antimicrobial compounds to prevent the spread of Bd and other pathogens. The companies are also working with FWS officials to come up with ways to identify species, not yet in commerce, that might become invasive; this risk assessment could be a stopgap approach to screening out potential wildlife diseases and would "say to the pet trade: 'Beware—don't deal with these,' " Meyers says.

Lips and other scientists are afraid such strategies won't be good enough. They would like more details about exactly how companies do their testing and treatments. Under existing U.S. law, a company "could have 100% infected imports and there is nothing we can do," Lips says.

More broadly, researchers say the World Customs Organization should develop a tracking system for the amphibian trade, much as it monitors the movements of other goods. Mendelson, for one, says there's already enough evidence that North America should ban commercial salamander imports. Once the fungus arrives, it may be too late to prevent extinctions. "To do nothing," he says, "would be to ignore the lessons of the Bd disaster." ■

IMAGES: SRIVAS CHENNU

NEUROSCIENCE

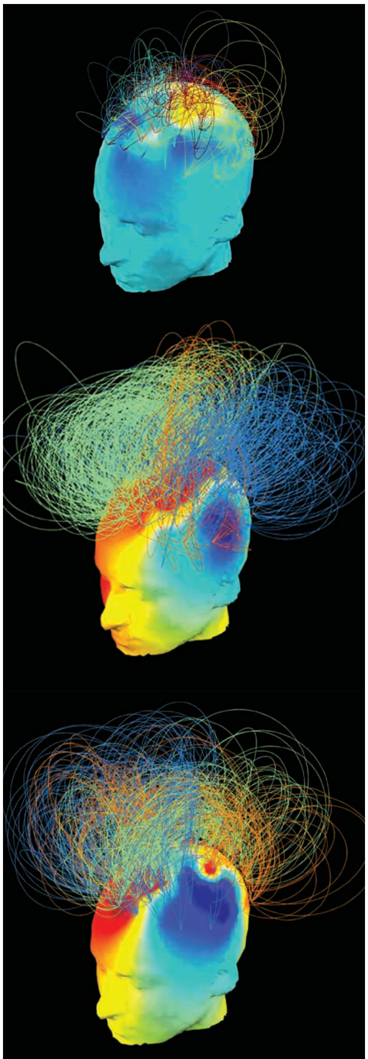
An easy consciousness test?

EEG studies detect awareness in locked-in people

By **Emily Underwood**

After several weeks in a coma, most people either die or transition into a "vegetative state." They may sometimes open their eyes, but they seem unaware of themselves or their surroundings. Recent high-profile studies have shown, however, that many are far from unconscious. Researchers now estimate that roughly 40% of people deemed vegetative are partially or even fully conscious but unable to communicate because of severe damage to brain regions that control movement.

This past weekend, more than 100 neuroscientists, neurologists, philosophers, and ethicists crammed into a small New York University auditorium in Greenwich Village in New York City, intent on sparing future brain injury patients from such misdiagnosis. Although the initial studies revealing this problem relied on modern, and expensive, brain imaging techniques, many at the meeting agreed that the most practical screening tool could be the century-old electroencephalography (EEG) test. EEG techniques are still too crude to reliably detect low-to-intermediate levels of consciousness, but they could provide a useful screen for people who are "locked-in"—highly aware but unable to communicate with the outside world, says Adrian Owen, a neuroscientist at the University of Western Ontario in London, Canada. These people—roughly one in five of those who are misdiagnosed as vegetative—"can do everything that you can do except for move and speak," Owen says.



Asked to imagine playing tennis, one "vegetative" person's EEG (*middle*) resembles a healthy control's (*bottom*) while another is unresponsive (*top*).

Unlike legal brain death, which can be diagnosed by testing basic brain stem responses, such as flinching in response to pain, "there is no gold standard" for discriminating between people in a vegetative state and those who are partly or fully conscious, explains Nicholas Schiff, a neurologist at Weill Cornell Medical College in New York City. In 2006, however, Owen's team demonstrated that it could communicate with a 23-year-old woman who had been diagnosed as vegetative, by asking her to imagine playing tennis while her brain was scanned with a functional magnetic resonance imaging (fMRI) machine. In response to Owen's discovery, the James S. McDonnell Foundation formed a consortium of researchers to generate inexpensive, portable methods for measuring borderline states of consciousness.

The collaboration has at times been fractious—last year, for example, Schiff and several other members of the consortium went head-to-head with Owen over a paper his team published in 2011 in *The Lancet*. It claimed that conscious but locked-in patients could be spotted by instructing them to imagine opening and closing their right fist or moving their feet and monitoring their brains just with EEG, which measures electrical activity of the brain using simple sensors on the scalp.

At the meeting, however, Schiff and other participants presented their own data supporting an EEG screen for locked-in people.

In one study, also published online on 24 October in *Annals of Neurology*, Schiff and colleagues examined EEG recordings taken from 44 people who had severe brain injury and found that four patients who showed very little or no responsiveness nevertheless had EEG patterns that looked similar to those of healthy controls. When the researchers tested a subset of the people on an fMRI test similar to the tennis task used in Owen's original study, only the four who had more normal-looking EEGs were able to communicate.

Owen points to another recent study, on which he was a co-author, as support for the potential of EEG recordings. A research group led by Srivas Chennu of the University of Cambridge performed a complex mathematical analysis on the EEG signals of healthy and vegetative people to determine how well their different brain regions were working together. In three of the 32 brain-injured patients, the EEG analyses resembled those of healthy people, the team reported on 16 October in *PLOS Computational Biology*. Follow-up studies showed that all three of those patients were conscious and able to communicate with researchers through the fMRI technique that involves imagining playing tennis.

These findings suggest that EEG may work "much better" as a screening tool for locked-in patients than fMRI, which has been shown to miss telltale signs of awareness in many patients, Schiff says. Ultimately, he adds, the goal is to come up with a bedside EEG screening test that could be administered in just 30 minutes. If patients passed the EEG test, physicians might be able to help them communicate by monitoring their brain activity with fMRI, he says.

Cheap and practical solutions such as EEG "have to be the answer" in the long term, Owen agrees, although they will need refining to detect levels of consciousness that lie somewhere between a vegetative state and full awareness. One promising approach, he says, is to apply strong magnetic pulses to the brain and use EEG to measure the electrical "echo" that comes back. Marcello Massimini, a neuroscientist at the University of Milan in Italy, has recently found that these echoes are highly complex in healthy people. But in people with severe brain damage, the echoes often fail to propagate throughout the brain, or they create uniform "ripples" of activity that don't convey much information, "like dropping a stone in a pond," Massimini says.

As EEG proves its value as a diagnostic tool for locked-in patients, Schiff says that one advantage could be decisive: "You can get an EEG test anywhere in the world." ■

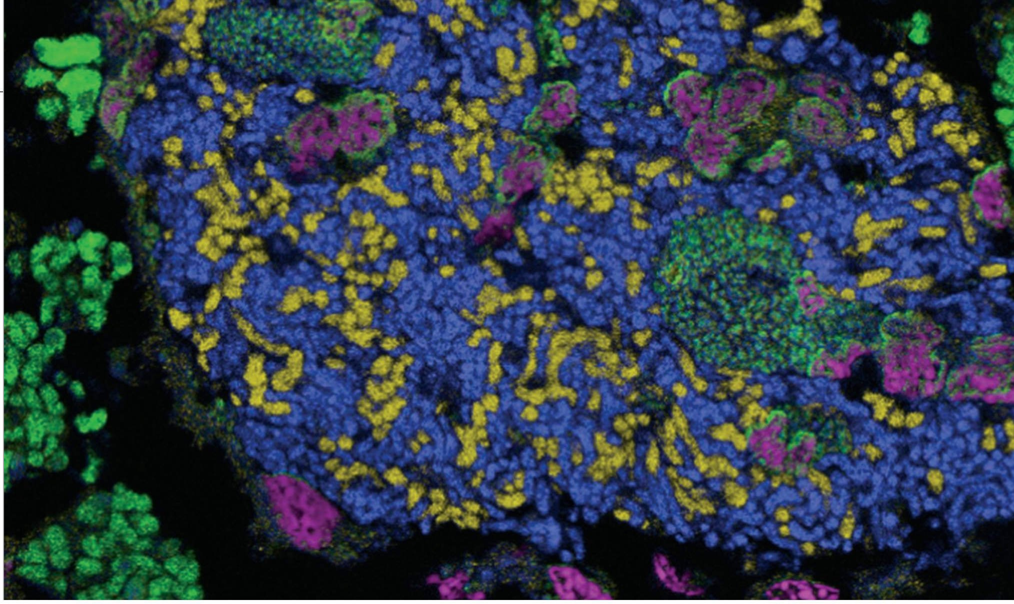


IMAGE: JAMES VAN LEUVEN AND JOHN MCCUTCHEON. PUBLISHED IN *CELL* 158:1270–1280

MICROBIOLOGY

Modern symbionts inside cells mimic organelle evolution

Long-term partnerships can result in extremes in genome reduction or expansion

By **Elizabeth Pennisi**, *in Irvine, California*

Some 2 billion years ago, primitive cells took in guests—and life was changed for good. A once free-living bacterium took up residence in a cell and gave rise to the organelles called mitochondria, which generate energy for their host cells by oxidizing sugars and also equipped some early life to survive Earth's increasing levels of oxygen. Another intracellular guest microbe became the ancestor of chloroplasts, the photosynthesizing organelles that made plants and algae possible.

Those momentous events, investigators are realizing, were not one-of-a-kind. Endosymbiosis, as a mutually beneficial relationship between an organism and a guest living inside its cells is called, is alive and well today, and has lessons to offer for how the process played out early in life history. "The line separating endosymbiont from organelle is very unclear indeed," said John McCutcheon, a biologist at the University of Montana, Missoula, earlier this month at "Symbioses becoming permanent," a meeting held here by the National Academy of Sciences and the Canadian Institute for Advanced Research.

At the meeting, biologists described how they are exploring those parallels. They are probing how insects such as cicadas and other multicellular organisms set up partnerships inside their cells with microbes that, like their ancient forerunners that became organelles, help provide essential nutrients and other services. Along the way, they are learning about the complex bargains host cells strike with their microbial partners—trade-offs that can explain some of the features of mitochondria and chloroplasts today.

Although DNA studies have convinced biologists that mitochondria evolved just once, from a type of microbe called an α-proteobacterium, the organelles have diversified wildly since then. Whereas modern free-living relatives of this bacterium harbor about 2000 genes across several million bases, its mitochondrial descendants all have far fewer genes—sometimes as few as three—and a wide range of genome sizes and shapes. The smallest mitochondrial genome is just 6000 bases long; human mitochondrial DNA stretches 16,000 bases. Some plants, in contrast, greatly expanded the genomes of their mitochondria, padding them with apparently inessential DNA: The biggest known, at 11 million bases, belongs to a flower called *Silene*, and it's divided into many circular chromosomes, some of which have no genes at all on them. Mitochondria have "been an endless reservoir of unconventional genomes," says David Smith, an evolutionary biologist at the University of Western Ontario in London, Canada. "They break all the rules."